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# IMPACT OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON SOIL ARTHROPODS. ONGOING STUDIES AT THE PROJECT SANGUINE WISCONSIN TEST FACILITY, 1973

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13. ABSTRACT


Possible long-term Sanguine impact on soil arthropods was studied in nine test plots and six control plots. Comparisons of test and control populations of mites and Collembola include statistical treatment of within-year and between-year numbers, predator proportions, Cryptostigmata: Collembola ratios, and Cryptostigmata: Mesostigmata ratios.

A striking result is the synchronicity and uniform amplitude of population cycles seen in a three-year perspective in the control and test plots. These similarities in population numbers are supported by analysis of variance in all cases but one.

The observations support a conclusion that following four years of operation, Sanguine electromagnetic fields have had no demonstrable effect on the arthropod populations under study.


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| prostigmata | | | | | | |
| mesostigmata | | | | | | |
| annual population curves | | | | | | |
| random natural fluctuation | | | | | | |
| biological impact of Sanguine fields | | | | | | |

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## 1.0 SUMMARY

Study of long-term impact of Sanguine electromagnetic fields at the Wisconsin Test Facility was continued in summer, 1973, with population analyses of 9 test and 6 control plots. The likelihood of biological effects on predominant soil animals from long-term exposure to Sanguine electromagnetic fields is assessed by comparing populations exposed to Wisconsin Test Facility fields with populations exposed to common 60 Hz electromagnetic fields of various intensities. Three plots (Main, Clover and New Hazleton) have been monitored for 3 years, 5 plots (New Clover, North Leg, GG, Hardwood and South Roadside) have been studied for 2 years. The original Hazleton plot was first sampled before antenna turn-on in summer, 1969, and each year since, making a total of 5 years. Comparisons of test and control populations of mites and Collembola include statistical treatment of within-year and between-year numbers, predator proportions , Cryptostigmata: Collembola ratios, and Cryptostigmata:Mesostigmata ratios.

In 1973, 13 out of 19 plots and subplots had fewer arthropods than in 1972. The even distribution (7 test and 6 control plots) rules out a Sanguine electromagnetic effect. This is supported by inter-year comparisons of the 3 Main test subplots. Although spaced only 30 yds apart and with the same flora, soil, and exposure, these subplots differed from each other as follows: in subplot Ala, the total count doubled from 1598 in 1972 to 3287 in 1973; in Alb, the count remained about the same, while in Alc, it decreased almost by half from 2357 to 1291. The same prevailed in the control subplots.

In test and control plots there appears to be a stabilized predator-prey system functioning at the microarthropod level.

This is indicated by the following evidence. In 1973, there were no significant differences i the proportions of predators (Mesostigmata, Prostigmata) in the populations of 7 out of 9 test and control comparisons for the entire summer and on a monthly basis. In 8 out of 11 test plots (73%) and in 5 out of 8 control plots (63%) there was also no significant shift in proportions of predators between 1972 and 1973. The 6 significant shifts occurred equally among test and control populations.

Prostigmates and mesostigmates in 1973 continued to have similar densities in paired test and control plots, as they did in 1971 and 1972. These micro-predators make up about 15% of the arthropods surveyed, with 7 to 30% their approximate limits. It is noteworthy that after 4 years of Sanguine operation the ratios Cryptostigmata:Collembola (the numerically dominant arthropod groups) are roughly the same in the Old Hazleton test and control plots. Furthermore, they approximate the 1969 pre-treatment ratios.

Also noteworthy is the synchronicity and uniform amplitude of population cycles seen in 3-year perspective in the paired plots. This is best illustrated by Collembola and Cryptostigmata of the Hazleton plots and of the Main plots. These similarities in population numbers are supported by analysis of variance in all cases but one.

The foregoing observations support a conclusion that, following 4 years of operation, Sanguine electromagnetic fields have had no demonstrable effect on the arthropod populations under study.

## 2.0 INTRODUCTION

The soil arthropod census as a possible measure of Sanguine biological impact was begun in 1969 with a single pair of plots--the Hazleton test and control plots--and continued in 1970. In 1971, the census was enlarged to include five test plots and three control plots, and in 1972, it was further expanded to eleven test and seven control plots (Greenberg 1972, 1973). This report for 1973 presents observations on nine test and six control plots--the 60-Hertz and one other test plot were obliterated by a bulldozer and inundated (not Project Sanguine related), respectively. The loss of the 60-Hertz plot is particularly regrettable because it represents more than a 20-year exposure of the biota to electric fields that were 10,000 X (1971) to 18,000 X (1972) greater than ambient. Although this exposure was roughly around-the-clock and seven-days-a-week, there had been no substantial changes in total numbers of Collembola, Prostigmata, Mesostigmata, and Cryptostigmata.

This report contains analyses of three paired plots under investigation for three years, and other pairs that have been studied for two years; the original Hazleton plots have been monitored for five years. Comparisons of test and control populations include statistical analysis of within-year and between-year predator proportions, population densities, Cryptostigmata:Collembola ratios, and Cryptostigmata:Mesostigmata ratios.

Some confusion regarding the purpose of these studies has become evident from comments received on previous reports. It may

be helpful, then, to discuss the objective and several underlying principles involved in these studies before proceeding further.

The particular question which these yearly studies address is whether the low-level, nonionizing electromagnetic fields produced by the WTF operations are affecting several natural soil animal populations in an adverse way. These studies attempt to find whether such a relationship might exist by the process of comparative analyses of statistically-adequate numbers of soil animals from "paired" soil plots. These studies are not intended to show differences between populations in recently disturbed (by mechanical means) soils and relatively undisturbed soils. They are intended only to determine whether electromagnetic effects are evident between plots that are basically similar.

The criterion for selecting a "test" plot is that it is so located that the predominant ELF electromagnetic exposure is that produced by the WTF antennas. This criterion is satsified generally by selecting soil plots very near to, and preferably adjacent to, the existing antennas.

The electromagnetic criterion for selecting "control" plots is that the electromagnetic exposure predominant at the plot is produced from some ELF source other than the WTF.

This criterion usually is satisfied by finding a comparable plot far removed from the immediate Wisconsin Test Facility area

Certain localized differences occur between test and control plots which cannot be avoided. Insofar as is practical, however, control plots have been selected which exhibit basically the same natural characteristics as test plots used in these studies.

## 3.0 METHODS

### 3.1 SAMPLING SITES

The floral cover, location, and other features of each plot have been previously described in the reports for 1971 and 1972 (also Greenberg 1972, 1973). The plots are: Main test with its 3 subplots (Ala, Alb, Alc) and Main control with its 3 subplots (Bla, Blb, Blc); Clover test (A2) and control (B2), West or Old (A3) and East or New (A4) Hazleton tests and control (B3). Soil classifications of the above plots are given in the report for 1972 (see also Greenberg 1973). Soil classifications of the following plots are given in Table 1: North Leg test (A7) and control (B7); Hardwood test (A8) and control (B8); South Roadside test (A9) and control (B9); New Clover test (A10) and control (B2); GG test (A12) and control (B7) (Fig. 5). Soil analysis of each plot was made by borings immediately adjacent to the plot*.

### 3.2 SAMPLING SCHEDULE

Each test and control plot was sampled four times at approximately monthly intervals, from June to September, 1973. The schedule coincided within a few days with the sampling schedules of previous years.

*We thank Edward Neumann and James Wardensky, soil specialists for the Forestry Service of the U.S. Department of Agriculture, for analysing and classifying the soils (see also R.S.A. Radtke, Chequamegon Soils, U.S.D.A., 115 pp., 1972.

## 3.3 SAMPLING DESIGN

The sampling design of previous years was retained, including coring, transportation, and extraction of samples. Essentially, 8 randomized core samples were taken from each plot at monthly intervals, except for the Main plots where 4 cores were taken from each of the 3 test subplots and from each of the 3 control subplots.

## 3.4 SANGUINE TEST FACILITY OPERATIONS

The step-wise increments in Sanguine antenna output starting with 10 amperes at inception in July 1969, and levelling off at 300 amperes in March 1971, have been graphed (Greenberg 1971). A buried antenna was added in the right-of-way of the North-South overhead antenna in late 1972 and became operational in Spring 1973. The average depth of this antenna is about 30 inches. The three antennas are operated in various modes according to operational and ecological experimental requirements. The maximum antenna current is almost always used when the antennas are operating (e.g., 300 amperes for the overhead antennas and 260 amperes for the underground antenna) and the frequency of operation is at or near 45 or 75 Hz.

Some experiments have called for CW operation and others for modulated operation. The modulation is a low chip rate (roughly 16 Hz) MSK. For example, during the 1972 calendar year, a modulated signal was used for 36% of the total operating time. During the 1973 calendar year, a modulated signal was used for 6% of the total operating time.

A summary of the operation of the Test Facility antennas is presented in Table 9. Table 9 provides a comparison of overhead

vs. underground antenna time and, also, shows the simultaneous operation of the antennas. This table represents 95% of the operational hours. The remaining 5% was at lower level currents for short-term experiments.

## 3.5 ELECTROMAGNETIC FIELD MEASUREMENTS

Electromagnetic field measurements at each plot were made in summer, 1973, by Henry Hegner of the IIT Research Institute. Instrumentation was the same as used in preceding years.

## 3.6 STATISTICAL TREATMENT

Analysis of variance was performed on all data. The data were transformed using the angular or arcsine transformation which is appropriate for proportions to prevent the variance from being a function of the mean. Tests were performed after the methods of Sokal and Rohlf (1969) using standard 2-way analyses of variance with replication for all tests except the Main test vs control which was tested using a 3-level nested anova. A single classification anova without a transform was used to compare the numbers of Collembola and Cryptostigmata in the Main, Clover, and Hazleton tests and controls. The CL about the mean were calculated with a formula that assumes a normal population with unknown variance (Huntsberger 1967).

## 4.0 RESULTS AND DISCUSSION

Soil types and drainage are given in Table 1; paired test and control soils are the same or are very similar and have the

same pH and upper strata characteristics.

Electric and magnetic field measurements were taken at each plot during summer, 1973, and are compared in Table 2 with data obtained in 1972. The measured variations between 1972 and 1973 are not unusual.

All of the test and associated control plots are significantly different in electric and magnetic field strengths as required for the study, although the E-field strength for the Clover control plot is larger than would be normally desired for a control site. This condition is due to the fact that the plot is located near a long buried pipeline which enhances the electric field somewhat.

It should be pointed out that the results obtained at six of the plots during 1973 deviate from the corresponding data obtained during 1972. These discrepancies are in the electric field strength data. For example, the E-field strength for the South Roadside test plot was larger in 1972 than in 1973, the GG roadside test plot was larger in 1973 than in 1972. Both of these test plots are directly above and near a buried antenna at a road crossing. Because of this fact, considerable variation in the E-field strength can be obtained due to the position of the probe wires within the plot. No attempt was made to position the probe wires within the plot in identical locations during 1972 and 1973 other than to place the probe wires approximately parallel and perpendicular to the antenna under test. Also, since these measurements were made with a one-meter probe, they are susceptible to local variations in surface earth conductivity.

Similar differences in data were obtained during the electric field strength measurements at the New Clover and the Hardwood test plots. Both of these plots are near the north leg of the overhead N/S antenna. As with the previous plots, E-field strength variations can be obtained due to the position of the probes within the plot with respect to the antenna under test, and because of local variations in surface earth conductivity.

One additional control plot had a decrease in its electric field strength during 1973. The decrease in field levels at the South Roadside control plot could be due to a localized variation in soil conductivity due to a change in moisture content, for example. Of course, from an electromagnetic point-of-view, the lower 1973 readings also increase the differences in electric field strength between the corresponding test and control plots.

The inter-year differences in electric fields cited above are relatively small and do not disturb the experimental designs because they reach a maximum 2-fold difference in only one instance (GG test, 45 Hz, E/W antenna). It is evident from Table 3 that E-fields at test plots are many times greater than they are in corresponding control plots, and thus satisfy the basic electromagnetic criteria for these studies.

Table 4 summarizes mean monthly counts of mites and Collembola per core sample per plot for the four sampling periods. Table 5 gives 95% confidence limits of mean summer populations.

Table 7 compares total numbers of microarthropods per plot in 1972 and 1973. The data show that in 13 out of 19 plots

total numbers decreased in 1973 (7 test and 6 control plots). Rainfall was considered a possible determinant and precipitation records for the study area were obtained from the U.S. Weather Bureau. These showed that from mid-April to mid-September total precipitation was 24.43 inches in 1972 and 25.98 inches in 1973. This small difference in precipitation over a 5-month period is probably unimportant. Large fluctuations in otal numbers were found in both the Main test and the Main control subplots. For example, test subplot Ala yielded a total of 1598 arthropods in 1972 and this doubled to 3287 in 1973; in Alb the counts remained approximately the same, while in Alc they decreased almost by half from 2357 in 1972 to 1291 in 1973. All groups of mites and Collembola participated in these inter-year shifts, upwards or downwards, with the one notable exception of Cryptostigmata in Ala which alone contributed to a doubling in 1973 (Table 8). These subplots are only about 10-30 yards apart and have essentially the same soil, plant cover, and exposure. We do not know what factor(s) are responsible for these differences in arthropod production but they are evidently not due to a Sanguine electromagnetic effect.

The four groups of arthropods under study divide fairly well into predators (Mesostigmata and Prostigmata) and prey (Collembola and Cryptostigmata). The former consume the latter and the latter break down litter thereby contributing to soil humification, and they also consume such microbiota as fungi and bacteria. Statistical analyses were made of predator-prey proportions in each test and control plot in 1972

and 1973. In 1973, there were no significant differences in 7 out of 9 comparisons of test and control pairs; except in two cases these proportions also did not differ significantly on a monthly basis (Table 7). Nor did they change significantly in the last two years in the majority of cases. Thus, 8 out of 11 test plots (73%) and 5 out of 8 control plots (63%) had a stable predator-prey system functioning at the microarthropod level. There were 6 significant shifts but these divided equally among test and control plots (Table 8). Micro-predators make up about 15% of total mites and springtails, with 7 to 30% their approximate limits (Figs. 1, 2).

With the exception of the Hardwood control (B8), all of the hardwood sites (A3, A4, B3, A8) exhibited a higher productivity as evidenced by total numbers of mites and springtails over the two-year period.

The observations that follow and the accompanying figures 1-4, deal with the Hazleton, Clover, and Main plots that have been monitored for 3 to 5 years.

Hazleton

After 4 years of ELF electromagnetic field exposure the ratio of Cryptostigmates to Collembola at the Old Hazleton test plot (A3) approximates the control and the 1969 pre-treatment ratios (Fig. 3). Note the regularity of the 3-year Cryptostigmatid population curves in the New Hazleton test plot (A4) matched by the annual oscillations of the control, at slightly lower amplitude (Fig. 2). Both populations appear to be well regulated and absence of any statistically significant difference (.25>P>.10) in their numbers over a period of 3 years reinforces the conclusion

that the mites are undergoing natural fluctuations unperturbed by Sanguine Test Facility operation. The same is true of the springtails although their curves show less symmetry ($P > .75$).

The typical dynamics appear to be a midsummer peak followed by a decline to about the level of our June sampling. We do not know if there is another population peak in the fall as reported for more southerly populations. We tend to doubt this as usually there is snow on the ground from 6 weeks after our last sampling to about 6 weeks before our first sampling. Our spring and fall numbers compare so consistently that it appears that we are observing the main pulse of one oscillation per year with a low overwintering mortality.

Clover

The red and white clover that was planted along the gas pipeline (control) and antenna right-of-ways (test) has now been largely replaced by grasses in the control plot and by grasses, wild strawberry, hawkweed, large leaved aster, etc. in the test plot. This floral succession may help to account for the absence of a uniform pattern of fluctuation among Collembola and cryptostigmatids in test and control plots. For example, test springtails had a fall peak in 1972 but not in 1973 (Fig. 1). This burst was preceded in 1971 and followed in 1973 by much lower numbers and indicates that in summer, 1972, constraints on population growth were relaxed, allowing a 10-fold rise instead of the usual 2- to 3-fold rise. Comparison of test and control springtails for 3 years underscores their unpredictability: in 1971, the two populations were in phase but the controls were more numerous ($p < .025$); in 1972, test and

control were wholly out of phase and controls were still more numerous ($p<.01$); in 1973 the two groups were in phase and the difference in their numbers was statistically highly insignificant ($p>.75$).

Main

Perhaps most noteworthy are the generally synchronous population curves for Collembola and cryptostigmatids seen in 3-year perspective (Fig. 1). This is even clearer when one connects the curves between years. This feature of test and control groups is supported by statistical analysis of Collembola ($.50>p>.25$) but not of Cryptostigmata ($.025>p>.01$). It is interesting that in this open habitat created by logging operations about a decade ago and which is only slowly being reclaimed, the springtails are much more tightly regulated than the oribatids, undergoing a seasonal doubling while oribatids triple.

Three years of observation reveals that the oribatid population crashes earlier in the control plots than in the test plots. The test plots are in a more open area and receive more direct sunlight than the control plots which are in a scrubby area that is overgrown by September. This may cause an earlier lowering of soil temperature in the control plots and consequently an earlier population crash. Fig. 4 reveals an increasing ratio of Cryptostigmata to Mesostigmata in the Main test and control plots during 1972 and 1973. This is due to an increase in the numbers of cryptostigmatid mites while mesostigmatids have held fairly constant or diminished slightly.

The evidence presented in this report supports a conclusion that microarthropod populations living in various habitats along the Sanguine antenna continue to be unaffected by its electromagnetic fields. This conclusion is further supported by data on oxygen consumption and respiratory quotient in slugs, two species of earthworms, wood lice, and red-backed salamanders taken from under the Sanguine antenna and from areas six to thirteen miles from the antenna. These data show no significant differences between test and control populations in any of the five species living in nature and exposed to Sanguine-generated fields for four years (Greenberg 1974).

## 5.0 ACKNOWLEDGEMENTS

We wish to thank Margaret Flowers for excellent technical assistance and Henry Hegner of the field staff of IIT Research Institute for making electric and magnetic field measurements at all experimental plots. This study was performed for the U. S. Naval Electronic Systems Command under contract N00039-72-C-0106 with IIT Research Institute.

## 6.0 LITERATURE CITED


Greenberg, B. 1972. Impact of extremely low frequency electromagnetic fields on soil arthropods. Environ. Entom., 1: 743-50.

____________. 1973. Do extreme low frequency electromagnetic fields affect soil arthropods? Ongoing studies at the Wisconsin Test Facility. Environ. Entom., 2: 643-52.

____________. 1974. Extremely low frequency antenna operation: Tests for possible impact on five naturally exposed animal populations. Jour. Invert. Path., in press.

Huntsberger, D. V. 1967. Elements of statistical inference. Allyn and Bacon, Boston. 398 p.

Sokal, R. R., and F. J. Rohlf. 1969. Biometry, the principles and practice of statistics in biological research. W. H. Freeman & Co., San Francisco, 757 p.

Table 1. Soil types in test and control plots.

| Test Site | Soil series | Slope | Drainage | Control Site | Soil series | Slope | Drainage |
|---|---|---|---|---|---|---|---|
| New Clover (A10) | IRON RIVER fine sandy loam | B | Moderately well to well | Clover (B2) | IRON RIVER going to FREON[1] | B | Moderately well to well |
| North Leg (A7) | GOGEBIC fine sandy loam | B | Moderate | North Leg (B7) | FREON wet variant (in transition zone)[1] | A (swamp) | Poor |
| GG (A12) | WORCESTER sandy loam | A (swamp) | Poor | | | | |
| Hardwood (A8) | IRON RIVER fine sandy loam | B | Moderately well to well | Hardwood (B8) | IRON RIVER fine sandy loam | B | Moderately well to well |
| South Roadside (A9) | IRON RIVER fine sandy loam | B | Moderately well to well | South Roadside (B9) | PADUS (regular PADUS over gravel)[1] | B | Well |

[1] The same type or a closely related type with the same pH and upper strata characteristics.

Table 2. Comparison of Electric and magnetic fields at test and control plots. Antenna current 300 amperes

| Test location | Electric field strength (millivolts/meter) | | | | | | | | Magnetic flux density (gauss) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E/W antenna | | | | N/S antenna | | | | E/W antenna | | | | N/S antenna | | | |
| | (45 Hz) | | (75 Hz) | | (45 Hz) | | (75 Hz) | | (45 Hz) | | (75 Hz) | | (45 Hz) | | (75 Hz) | |
| | 1972 | 1973 | 1972 | 1973 | 1972 | 1973 | 1972 | 1973 | 1972 | 1973 | 1972 | 1973 | 1972 | 1973 | 1972 | 1973 |
| Main test (A1a) | 122.00 | 123.00 | 199.00 | 178.00 | 32.00 | 36.00 | 41.00 | 40.00 | 0.049 | 0.080 | 0.061 | 0.090 | - | - | - | - |
| Main test (A1b) | 116.00 | 91.00 | 186.00 | 152.00 | 28.00 | 33.00 | 31.00 | 34.00 | 0.036 | 0.033 | 0.032 | 0.044 | - | - | | - |
| Main test (A1c) | 147.00 | 119.00 | 227.00 | 184.00 | 31.00 | 42.00 | 43.00 | 36.00 | 0.045 | 0.040 | 0.041 | 0.042 | - | - | - | - |
| Main control (B1a) | 1.70 | * | 1.19 | 1.19 | 2.00 | 1.90 | 1.48 | 1.50 | - | * | - | - | - | - | - | - |
| Main control (B1b) | 2.35 | * | 1.21 | 1.60 | 2.56 | 2.76 | 2.23 | 2.20 | - | * | - | - | - | - | - | - |
| Main control (B1c) | 2.15 | * | 1.49 | 1.49 | 2.48 | 2.40 | 1.86 | 2.05 | - | * | - | - | - | - | - | - |
| Old clover test (A2) | 26.00 | 118.00 | 208.00 | 171.00 | 32.00 | 38.00 | 28.00 | 45.00 | 0.061 | 0.082 | 0.064 | 0.076 | - | - | - | - |
| New clover test (A10) | 5.04 | 4.30 | 5.66 | 6.20 | 108.00 | 136.00 | 164.00 | 230.00 | - | - | - | - | 0.091 | 0.140 | 0.085 | 0.091 |
| Clover control (B2) | 25.90 | * | 14.40 | 14.70 | 31.80 | 52.00 | 14.20 | 19.90 | - | - | - | - | - | - | - | - |
| GG test (A12) | 10.00 | 235.00 | 153.00 | 270.00 | 14.20 | 26.00 | 18.10 | 29.50 | 0.80 | 0.84 | 0.75 | 0.88 | - | - | - | - |
| North Leg test (A7) | 2.80 | 2.97 | 1.97 | 2.20 | 590.00 | 580.00 | 528.00 | 568.00 | - | - | - | - | 0.031 | [illegible] | 0.035 | 0.035 |
| North Leg control (B7) | 1.19 | * | 0.63 | 0.87 | 1.45 | 1.70 | 0.48 | 0.39 | - | - | - | - | - | - | - | - |

Table 2 (*Continued*)

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Old Hazleton test (A3) | 2.55 | 2.62 | 3.52 | 3.21 | 2500.00 | 2480.00 | 2560.00 | 2410.00 | - | - | - | - | 0.016 | 0.020 | 0.015 | 0.018 |
| New Hazleton test (A4) | 1.80 | 1.60 | 1.51 | 1.35 | 890.00 | 784.00 | 985.00 | 376.00 | - | - | - | - | 0.016 | 0.016 | 0.015 | 0.015 |
| Hazleton control (B3) | 2.94 | * | 2.42 | 2.40 | 3.33 | 3.15 | 2.90 | 2.55 | - | * | - | - | - | - | - | - |
| Hardwood test (A8) | 1.36 | 5.30 | 4.45 | 5.70 | 70.40 | 89.00 | 93.00 | 149.00 | - | - | - | - | 0.031 | [illegible] | 0.033 | 0.024 |
| Hardwood control (B8) | 1.34 | * | 0.70 | 0.71 | 1.43 | 1.26 | 0.93 | 0.95 | - | * | - | - | - | - | - | - |
| South Roadside test (A9) | 9.00 | 8.70 | 9.92 | 8.15 | 143.00 | 106.00 | 291.00 | 176.00 | - | - | - | - | 0.15 | 0.25 | 0.20 | 0.25 |
| South Roadside control (B9) | 1.00 | * | 0.73 | 0.10 | 1.00 | 1.20 | 0.65 | 0.032 | - | * | - | - | - | - | - | - |

- *Magnetic field density less than 0.001 gauss.*

* No measurements taken here in 1973.

Table 3. Magnitude of the difference between electric fields at test and control plots at 75 Hz.[a]

| Test series | Test/Control |
|---|---|
| Main[c] | 95-105X |
| Old Clover[c] | 12X |
| New Clover[b] | 12X |
| North Leg[b] | 1456X |
| GC[c] | 310X |
| Old Hazleton[b] | 945X |
| New Hazleton[b] | 344X |
| Hardwood[b] | 157X |
| South Roadside[b] | 5500X |

[a] In every case, the E-fields are larger in the test plots by the figure shown.

[b] NS antenna operating.

[c] EW antenna operating.

Table 4. Monthly means/core of mites & Collembola

| TEST | | | | | | CONTROL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Month | Mesostig-mata | Prostig-mata | Crypto-stigmata | Collem-bola | Site | Month | Mesostig-mata | Prostig-mata | Crypto-stigmata | Collem-bola |
| Main (A1) | June | 7.33 | 4.5 | 50.67 | 17.92 | Main (B1) | June | 9.5 | 3.17 | 30.83 | 24.33 |
| | July | 12.75 | 8.92 | 102.33 | 28.58 | | July | 10.83 | 8.5 | 61.5 | 36.17 |
| | August | 13.08 | 13.33 | 121.17 | 36.5 | | August | 9.73 | 9.09 | 88 | 43.73 |
| | Sept. | 11.58 | 8.92 | 103.5 | 20.67 | | Sept. | 6.67 | 3.25 | 30.17 | 18.5 |
| Clover (A2) | June | 4.12 | 5 | 17.62 | 46.25 | Clover (B2) | June | 1.62 | 1.5 | 5.87 | 34.37 |
| | July | 3.12 | 2.62 | 16.12 | 11.5 | | July | .87 | 2.12 | 6.62 | 17.25 |
| | August | 5.75 | 4.5 | 57.37 | 20.87 | | August | 3 | 1.12 | 21.25 | 26.5 |
| | Sept. | 3.5 | 2 | 25.75 | 18.12 | | Sept. | 6.12 | .75 | 23.25 | 23.87 |
| New Clover (A10) | June | 7.25 | 2.75 | 25 | 50.87 | | | | | | |
| | July | 2.5 | 2.37 | 25.75 | 23.25 | | | | | | |
| | August | 3.25 | 1.62 | 22.37 | 44.25 | | | | | | |
| | Sept. | 6.25 | 1.5 | 58 | 29.25 | | | | | | |
| Old Hazleton (A3) | June | 3.37 | 1.25 | 64.37 | 34.62 | Hazleton (B3) | June | 6.87 | 5.12 | 40.87 | 46 |
| | July | 3.37 | 5.62 | 39.25 | 34.75 | | July | 11.12 | 11.25 | 57.87 | 52.5 |
| | August | 7.75 | 3.37 | 52.12 | 42.87 | | August | 4.12 | 8.25 | 90.62 | 50.5 |
| | Sept. | 4.25 | 1.62 | 69.12 | 24.37 | | Sept. | 9.87 | 9.5 | 81.75 | 60.87 |
| New Hazleton (A4) | June | 9 | 5.37 | 99 | 49.87 | | | | | | |
| | July | 12 | 10.75 | 129.62 | 52 | | | | | | |
| | August | 10.62 | 10 | 113.5 | 71.5 | | | | | | |
| | Sept. | 8.37 | 4.62 | 45 | 37.25 | | | | | | |
| North Leg (A7) | June | 1.37 | 1.5 | 21.87 | 13.37 | North Leg-GG (B7) | June | 8.25 | 3.37 | 37.12 | 10.75 |
| | July | 3 | 6 | 39.37 | 17.87 | | July | 13.37 | 6.87 | 64 | 12.62 |
| | August | 2.5 | 1.12 | 17.62 | 17.37 | | August | 14.37 | 2.12 | 58.5 | 3.5 |
| | Sept. | 1.62 | .5 | 28.37 | 9.5 | | Sept. | 28.25 | 2.5 | 113.75 | 3.75 |
| G G (A12) | June | 6 | 7.37 | 12 | 7.25 | | | | | | |
| | July | 10.37 | 4.87 | 14.5 | 7.87 | | | | | | |
| | August | 3 | 2.12 | 15 | 12.12 | | | | | | |
| | Sept. | 7.62 | 6.75 | 52.87 | 10.87 | | | | | | |
| Hardwood (A8) | June | 4.25 | 10.37 | 44.12 | 26.5 | Hardwood (B8) | June | 2 | 4.25 | 3.87 | 17.75 |
| | July | 4.75 | 9.5 | 47 | 33.87 | | July | 2.87 | 2.62 | 8.75 | 16.75 |
| | August | 4.37 | 9.5 | 31.5 | 28.75 | | August | 1.87 | 1.62 | 8.37 | 20.87 |
| | Sept. | 4.5 | 10.12 | 52.12 | 21.37 | | Sept. | 2.62 | 2.37 | 8.25 | 26.12 |
| South Roadside (A9) | June | 5.37 | 15 | 25.12 | 32.75 | South Roadside (B9) | June | 7.75 | 6 | 36.62 | 18 |
| | July | 6.37 | 10 | 26.37 | 11 | | July | 5.12 | 5.5 | 27.87 | 11.12 |
| | August | 2.5 | 5.5 | 27.12 | 12.12 | | August | 13.75 | 10.5 | 81.12 | 20.37 |
| | Sept. | 3.62 | 4 | 38.62 | 13.87 | | Sept. | 32 | 10.25 | 94.5 | 22.12 |

Table 5. 95 percent confidence limits of mean numbers of arthropods per core sample.

| | Mesostigmata | | Prostigmata | | Cryptostigmata | | Collembola | |
|---|---|---|---|---|---|---|---|---|
| | Test | Control | Test | Control | Test | Control | Test | Control |
| Main | 11.2 (8.6-13.8) | 9.2 (5.8-12.5) | 8.9 (6.9-11) | 5.9 (3.7-8.2) | 94.4 ([illegible]-124.3) | 49.7 (31.2-68.2) | 25.9 (19.6-32.3) | 30.4 (23.1-37. ) |
| Clover | 4.1 (2.7-5.5) | 2.9 (1.8-4.0) | 3.5 (2.2-4.9) | 1.4 (.7-2.0) | 29.2 (16.[illegible].3) | 14.2 (9.4-19.1) | 24.2 (17.3-31.0) | 25.5 (18.5-32. ) |
| New Clover | 4.8 (3.0-6.6) | 2.9 (1.8-4.0) | 2.1 (1.2-2.9) | 1.4 (.7-2.0) | [illegible]2.6 (15.4-5[illegible].1) | 14.2 (9.4-19.1) | 36.9 (23.6-50.2) | 25.5 (18.5-32. ) |
| Old Hazleton | 4.7 (1.7-7.6) | 8.0 (5.7-10.3) | 3.0 (1.2-4.7) | 8.5 (6.4-10.7) | [illegible].2 (37.3-75.1) | 67.8 (38.6-96.9) | 34.2 (26.3-42.0) | 52.5 (42.7-62. ) |
| New Hazleton | 9.7 (6.3-13.0) | 8.0 (5.7-10.3) | 8.0 (5.2-10.8) | 8.5 (6.4-10.7) | 96.8 (82.4-111.1) | 67.8 (38.6-96.9) | 52.7 (36.3-69.0) | 52.5 (42.7-62. ) |
| North Leg | 2.1 (1.3-2.9) | 9.4 (6.4-12.4) | 2.3 (1.1-3.4) | 3.2 (1.9-4.5) | 29.9 (20.4-39.4) | 47.0 (35.1-58.9) | 14.5 (11.3-17.7) | 9.1 (6.3-11.8) |
| G G | 6.7 (4.0-9.5) | 9.4 (6.4-12.4) | 5.3 (3.5-7.1) | 3.2 (1.9-4.5) | 23.6 (15.6-31.6) | 47.0 (35.1-58.9) | 9.5 (7.4-11.6) | 9.1 (6.3-11.8) |
| Hardwood | 4.5 (3.2-5.7) | 2.3 (1.6-3.1) | 9.9 (8.0-11.7) | 2.7 (1.9-3.5) | 43.7 (31.5-55.9) | 7.3 (5.4-9.2) | 27.6 (20.7-34.6) | 20.4 (14.8-25. ) |
| South Roadside | 4.5 (3.2-5.8) | 11.1 (7.6-14.4) | 8.6 (5.4-11.8) | 9.2 (6.4-11.9) | 29.3 (22.9-35.7) | 59.7 (37.5-81.[illegible]) | 17.4 (12.4-22.5) | 17.9 (14.7-21. ) |

Table 6. Population densities of soil arthropods in 1972 and 1973.[1]

| Site | | 1972 Prostigmata | 1972 Mesostigmata | 1972 Cryptostigmata | 1972 Collembola | 1972 Total | 1973 Prostigmata | 1973 Mesostigmata | 1973 Cryptostigmata | 1973 Collembola | 1973 Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Main test | A1a | 156 | 210 | 856 | 376 | 1598 | 186 | 208 | 2653 | 240 | 3287 |
| | A1b | 266 | 181 | 1080 | 512 | 2039 | 149 | 230 | 1150 | 634 | 2163 |
| | A1c | 180 | 228 | 1304 | 645 | 2357 | 93 | 99 | 729 | 370 | 1291 |
| Main control | B1a | 201 | 267 | 1142 | 471 | 2081 | 64 | 156 | 959 | 436 | 1615 |
| | B1b | 138 | 177 | 508 | 327 | 1150 | 141 | 189 | 796 | 487 | 1613 |
| | B1c | 138 | 214 | 852 | 624 | 1828 | 85 | 94 | 772 | 546 | 1497 |
| Clover test | A2 | 124 | 210 | 1377 | 1080 | 2791 | 113 | 132 | 935 | 774 | 1954 |
| New Clover test | A10 | 70 | 184 | 874 | 1408 | 2536 | 66 | 154 | 1049 | 1181 | 2450 |
| Clover control | B2 | 77 | 130 | 378 | 1556 | 2141 | 44 | 93 | 456 | 816 | 1409 |
| Old Hazleton test | A3 | 88 | 101 | 1787 | 1243 | 3219 | 95 | 150 | 1799 | 1093 | 3137 |
| New Hazleton test | A4 | 341 | 553 | 3428 | 2212 | 6534 | 256 | 310 | 3097 | 1685 | 5348 |
| Hazleton control | B3 | 231 | 361 | 2033 | 2227 | 4852 | 273 | 256 | 2169 | 1679 | 4377 |
| North Leg test | A7 | 43 | 51 | 865 | 450 | 1409 | 73 | 68 | 958 | 465 | 1564 |
| G G test | A12 | 238 | 210 | 702 | 547 | 1697 | 169 | 216 | 755 | 305 | 1445 |
| North Leg - G G control | B7 | 86 | 280 | 1731 | 381 | 2478 | 119 | 514 | 2187 | 245 | 3065 |
| Hardwood test | A8 | 406 | 213 | 1479 | 1081 | 3179 | 316 | 143 | 1398 | 884 | 2741 |
| Hardwood control | B8 | 154 | 167 | 463 | 659 | 1443 | 87 | 75 | 234 | 652 | 1048 |
| S. Roadside test | A9 | 234 | 140 | 640 | 606 | 1620 | 276 | 143 | 938 | 558 | 1915 |
| S. Roadside control | B9 | 329 | 405 | 2474 | 742 | 3950 | 258 | 341 | 1921 | 573 | 3093 |

[1] Each figure is the summer total for the 4 monthly samples.

Table 7. Analysis of variance and mean proportions of predators in paired plots.

| Site | Average propor. predators[1] in test | Average propor. predators in test | Test vs control | Months |
|---|---|---|---|---|
| Main (A1, B1) | .1614 | .1731 | n.s.[2] | n.s. |
| Clover (A2, B2) | .1312 | .0979 | n.s. | n.s. |
| New Clover (A10, B2) | .1002 | .0979 | n.s. | n.s. |
| Old Hazleton (A3, B3) | .0759 | .1436 | $p<.001$ | $p\sim.024$ |
| New Hazleton (A4, B3) | .1098 | .1436 | n.s. | n.s. |
| North Leg (A7, B7) | .0911 | .2060 | $p<.001$ | n.s. |
| G G (A12, B7) | .2773 | .2060 | n.s. | n.s. |
| Hardwood (A8, B8) | .1850 | .1610 | n.s. | n.s. |
| S. Roadside (A9, B9) | .2009 | .2014 | n.s. | $.005<p<.01$ |

[1] Prostigmata and Mesostigmata

[2] Not significant at the .05 level of significance.

Table 8. Inter-year analysis of variance and mean proportions of predators in paired plots.

| Site | | $\bar{X}$ 1973 | $\bar{X}$ 1972 | 1973 vs 1972 |
|---|---|---|---|---|
| Main test | A1a | .1438 | .2766 | $.001 < p < .005$ |
| | A1b | .1848 | .2205 | n.s. |
| | A1c | .1557 | .1864 | n.s. |
| Main control | B1a | .1413 | .2710 | $.001 < p < .005$ |
| | B1b | .2245 | .2681 | n.s. |
| | B1c | .1534 | .2047 | n.s. |
| Clover test | A2 | .1312 | .1473 | n.s. |
| New Clover test | A10 | .1002 | .1141 | n.s. |
| Clover control | B2 | .0979 | .0968 | n.s. |
| Old Hazleton test | A3 | .0759 | .0674 | n.s. |
| New Hazleton test | A4 | .1098 | .1425 | $p \sim .025$ |
| Hazleton control | B3 | .1436 | .1275 | n.s. |
| North Leg | A7 | .0911 | .1231 | n.s. |
| G G Test | A12 | .2773 | .2934 | n.s. |
| North Leg-GG control | B7 | .2060 | .1457 | $p \sim .005$ |
| Hardwood test | A8 | .1850 | .2061 | n.s. |
| Hardwood control | B8 | .1610 | .2246 | $p \sim .025$ |
| S. Roadside test | A9 | .2009 | .2502 | $p \sim .05$ |
| S. Roadside control | B9 | .2014 | .1916 | n.s. |

[1] Not significant at the .05 level of significance.

## Table 4

## SUMMARY OF OPERATION (SPRING 1973 TO PRESENT)

### Number of Hours/Month

| | Mode | | | | |
|---|---|---|---|---|---|
| Month/Year | NSOH | EW | NSB | NSOH & EW | NSB + EW |
| March 1973 | 93.5 | 20.5 | - | - | - |
| April | 82.0 | 75.0 | 61.7 | - | 7.5 |
| May | 38.0 | 81.1 | - | - | 60.0 |
| June | 9.4 | 59.1 | 76.4 | - | - |
| July | 59.1 | 12.9 | 1.6 | - | - |
| August | 11.6 | 10.9 | 10.1 | 16.7 | - |
| September | - | 5.8 | 7.0 | 131.0 | 6.2 |
| October | 11.2 | 74.3 | 3.7 | 8.0 | - |
| November | - | 74.1 | - | 97.5 | - |
| December | 5.2 | 70.3 | - | - | - |
| January 1974 | 4.9 | 1.3 | 0.2 | 205.9 | 58.6 |
| February | - | - | - | 22.0 | - |
| March | 110.3 | - | - | 129.7 | - |
| April | - | - | 26.4 | - | - |

NSOH - North-South Overhead Antenna at 300A

EW - East-West Overhead Antenna at 300A

NSB - North-South Buried Antenna at 260A

NSOH & EW - North-South Overhead and East-West Antenna at 300A

NSB & EW - North-South Buried Antenna at 260A and East-West Antenna at 300A

Fig. 1. Three-year summer population curves of mites and collembolans in Main and Clover experimental plots, based on monthly means.

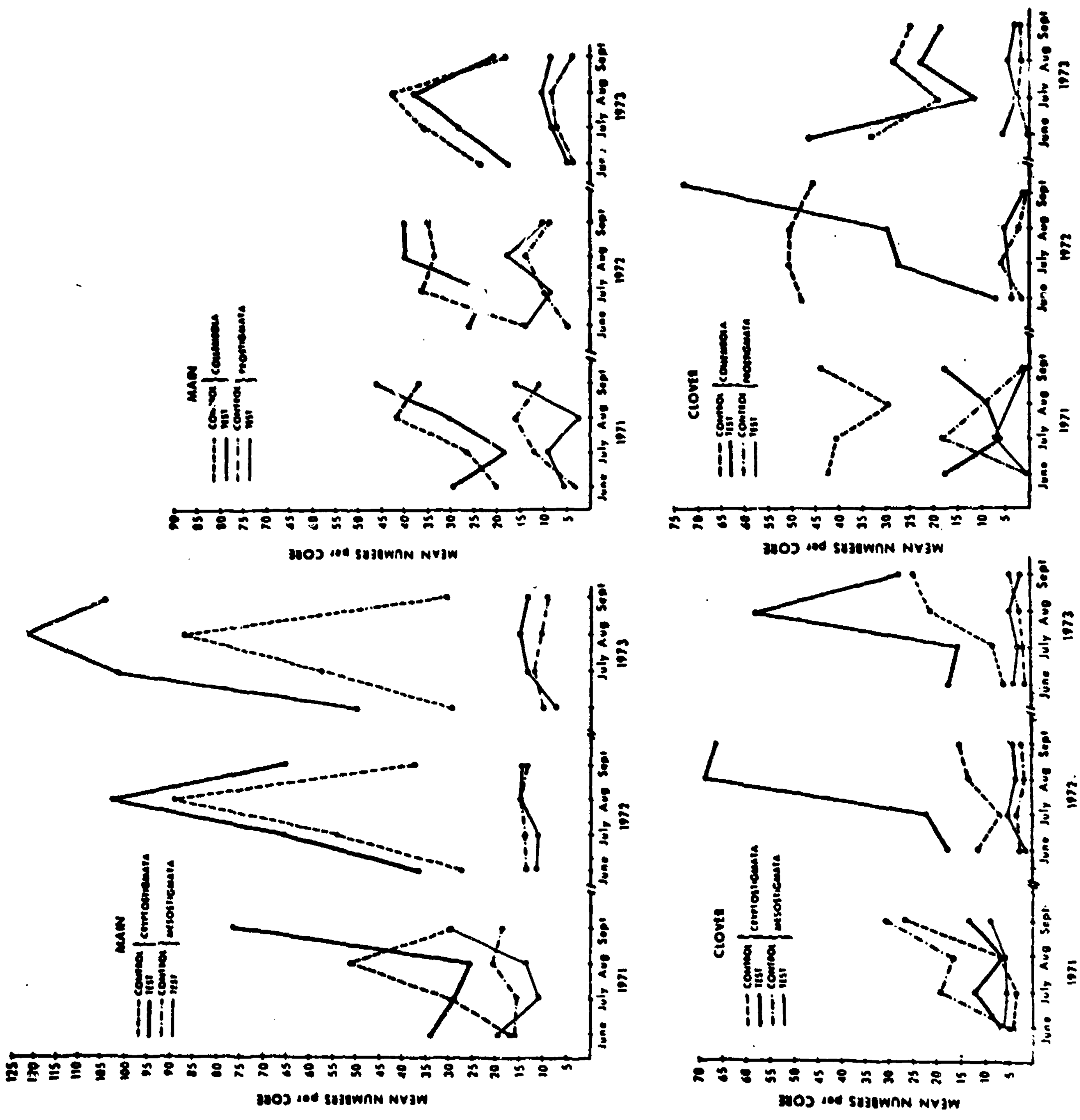
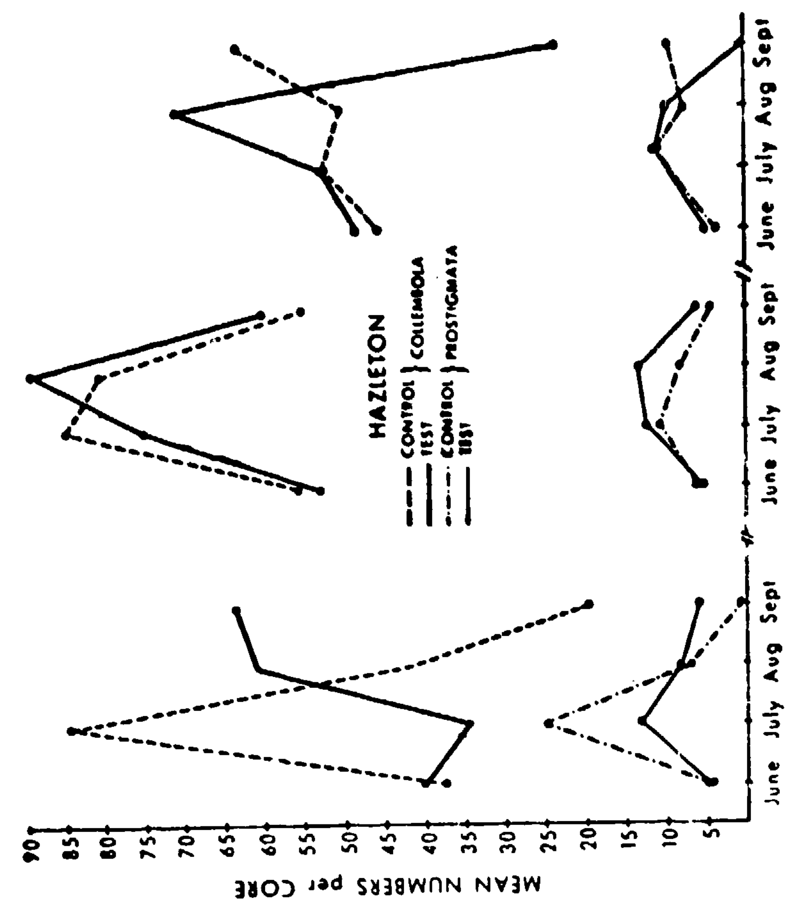
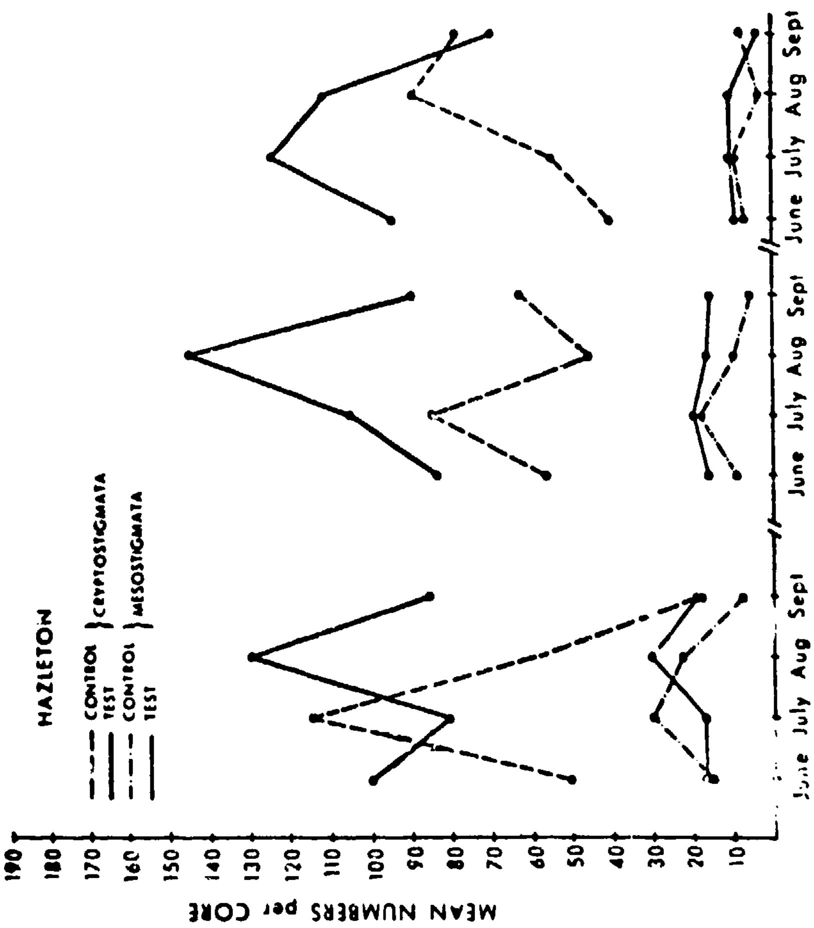

MAIN
CONTROL
TEST
CRYPTOSTIGMATA
MESOSTIGMATA
COLLEMBOLA
PROSTIGMATA
CLOVER
MEAN NUMBERS per CORE
June July Aug Sept
1971
1972
1973

Fig. 2. Three-year summer population curves of mites and collembolans in Hazleton experimental plots, based on monthly means.



MEAN NUMBERS per CORE
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
HAZLETON
CONTROL
TEST
COLLEMBOLA
CONTROL
TEST
PROSTIGMATA
June July Aug Sept
1971
June July Aug Sept
1972
June July Aug Sept
1973

MEAN NUMBERS per CORE
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
HAZLETON
CONTROL
TEST
CRYPTOSTIGMATA
CONTROL
TEST
MESOSTIGMATA
June July Aug Sept
1971
June July Aug Sept
1972
June July Aug Sept
1973

Fig. 3. Ratio of Cryptostigmata to Collembola in Hazleton (Northern Hardwood Forest) Test and Control Plots.

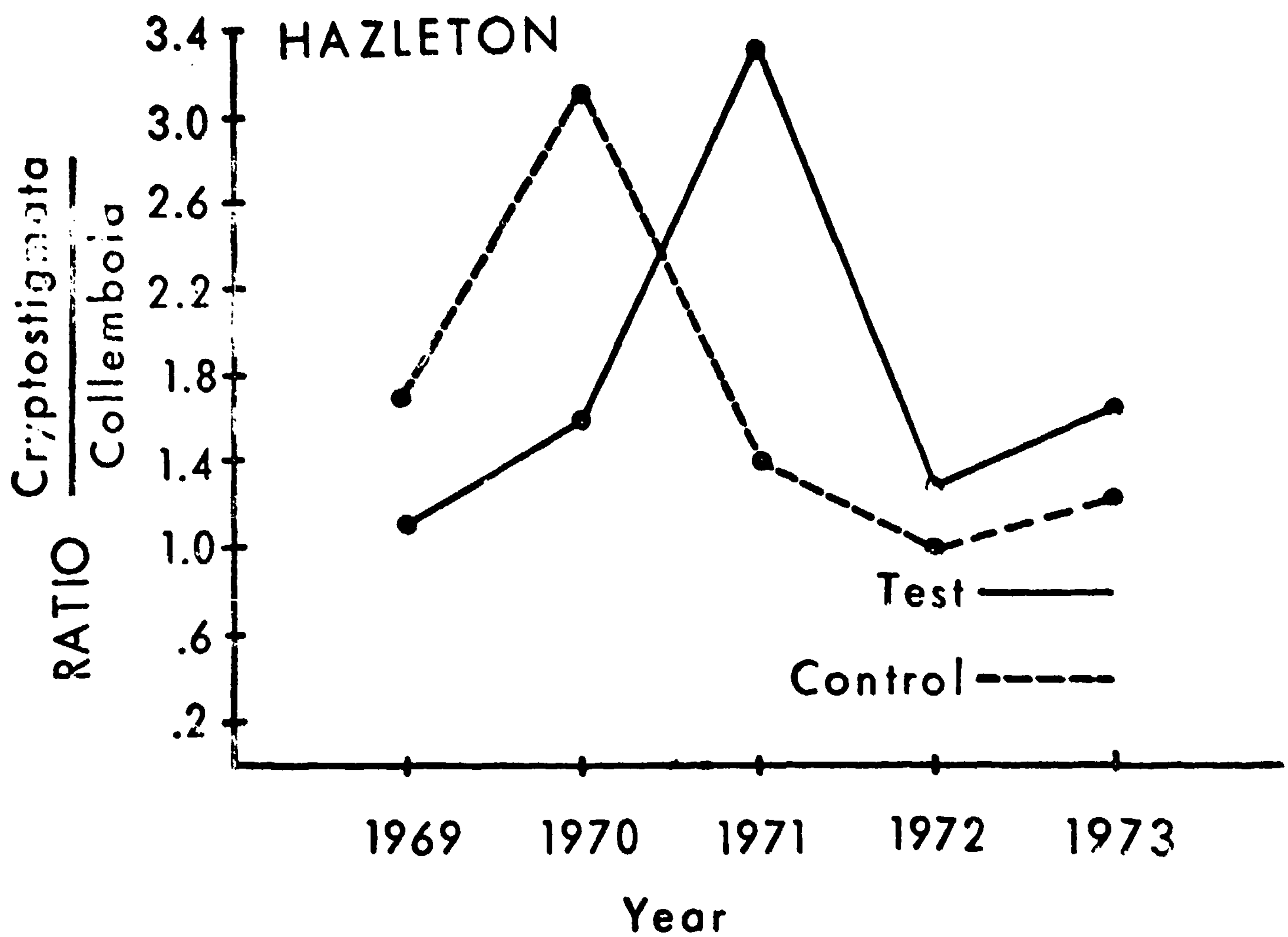

HAZLETON
RATIO Cryptostigmata / Collembola
3.4
3.0
2.6
2.2
1.8
1.4
1.0
.6
.2
1969
1970
1971
1972
1973
Year
Test
Control

Fig. 4. Three-year ratios of Cryptostigmata to Mesostigmata in Main plots show a relative increase in Cryptostigmata in test and control plots over the last two years.

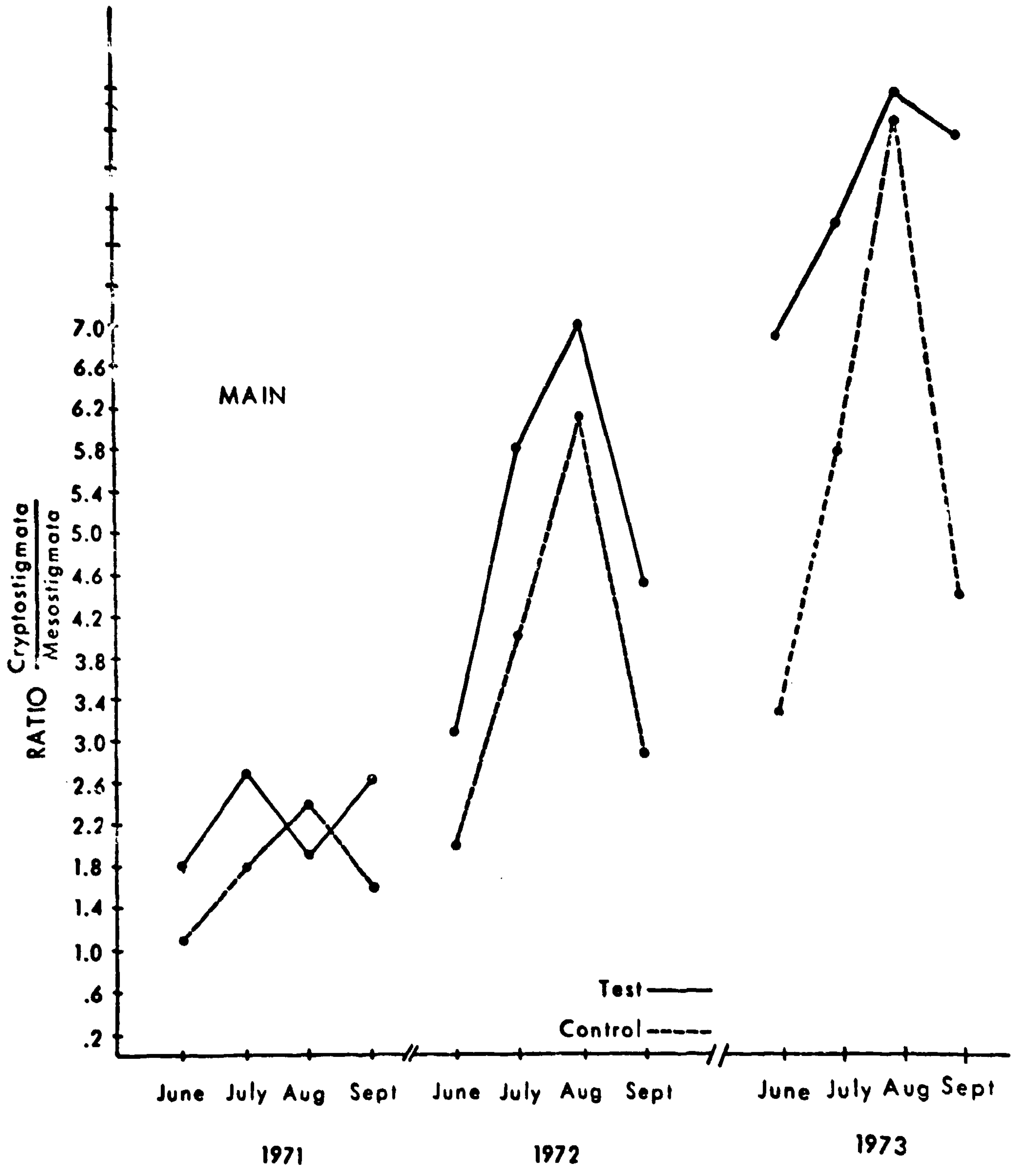
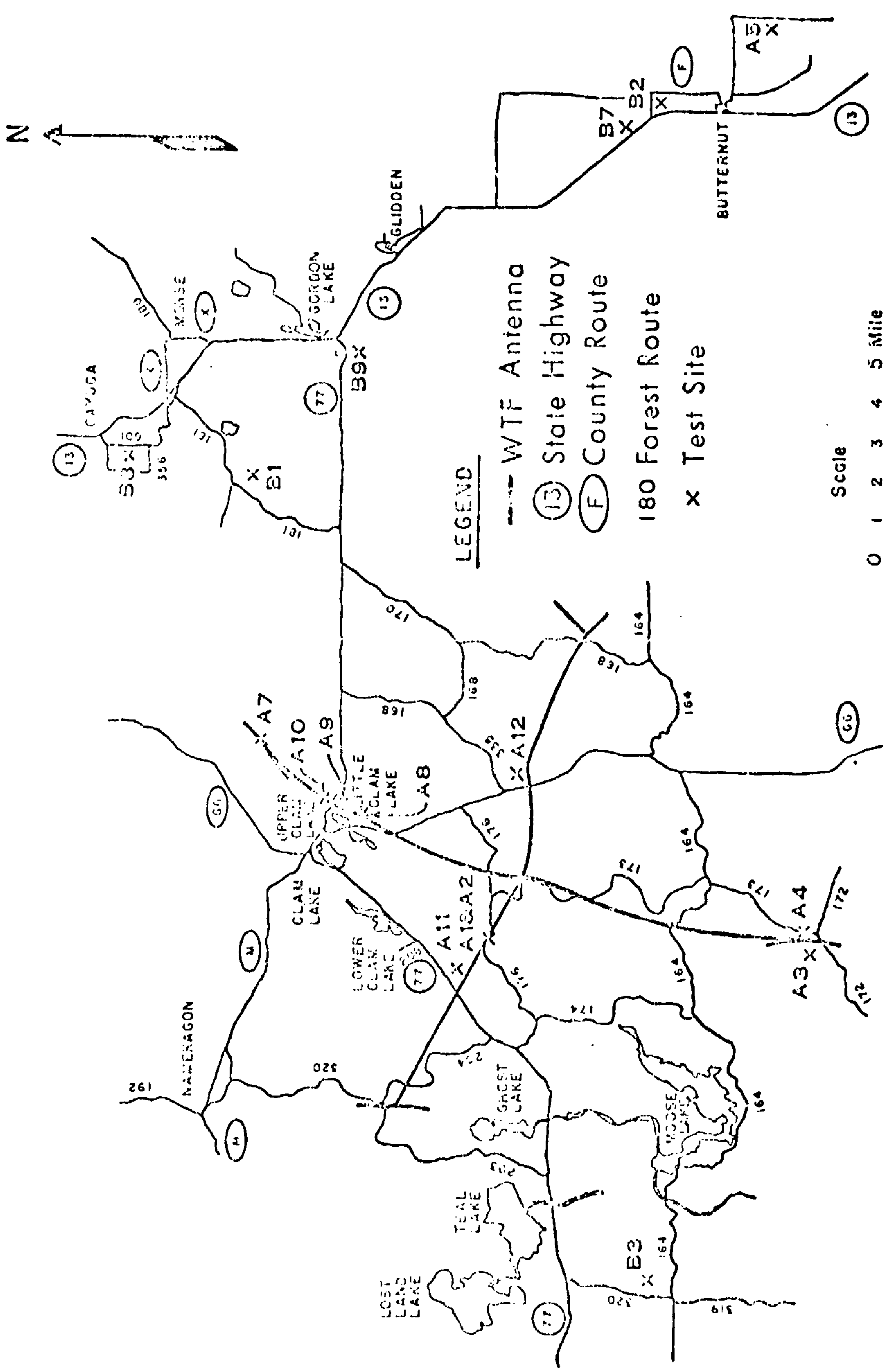

MAIN
RATIO Cryptostigmata / Mesostigmata
7.0
6.6
6.2
5.8
5.4
5.0
4.6
4.2
3.8
3.4
3.0
2.6
2.2
1.8
1.4
1.0
.6
.2
Test
Control
June July Aug Sept June July Aug Sept June July Aug Sept
1971
1972
1973

Fig. 5. Site locations for the Wisconsin Test Facility soil arthropod survey: Main test (1); Main control (B1); Clover test (A2); Clover control (B2); New clover test (A10); West leg test (A11); West Hazleton test (A3); East Hazleton test (A4); Hazleton control (B3); North leg test (A7); North leg control (B7); GG test (A12); Hardwood test (A8); Hardwood control (B8); South roadside test (A9); and South roadside control (B9).


N
LEGEND
WTF Antenna
13 State Highway
F County Route
180 Forest Route
x Test Site
Scale
0 1 2 3 4 5 Mile
GLIDDEN
BUTTERNUT
GORDON LAKE
MORSE
CAYUGA
UPPER CLAM LAKE
LITTLE CLAM LAKE
CLAM LAKE
LOWER CLAM LAKE
NAMEKAGON
GHOST LAKE
MOOSE LAKE
TEAL LAKE
LOST LAND LAKE
A3
A4
A5
A7
A8
A9
A10
A11
A1&A2
A12
B1
B2
B3
B7
B9
E3